Daylighting and Electric Lighting

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Benya Lighting Design

the collaborative for high performance schools

Eligibility Criteria

Criteria

- Your design can receive up to 10 points for Superior Energy Efficiency. Integrated lighting design is required for efficiency improvements. (Similar to LEED)
- You also get 1 point for elimination of light pollution by proper outdoor lighting techniques. (Similar to LEED)
- Another point is available for providing a 2% daylight factor in 75% of classrooms. (Similar to LEED).

Daylighting and Electric Lighting

Session Agenda

1. Design Criteria
2. Daylighting Principals
3. Daylighting Guidelines
4. Electric Lighting Equipment
5. Lighting Controls
6. Electric Lighting Guidelines
7. The CHPS Classroom

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Daylighting and Electric Lighting

Design Criteria

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Establish Basic Lighting and Daylighting Design Criteria

From the IESNA Lighting Handbook, 9th Edition

- Provide Lighting for Human Needs
- Balance Human Needs With Architecture, Site and Practical Considerations
- Balance These Needs With Economics and Environmental Considerations

Lighting for Human Needs

- Visibility and task performance. → **Use Current IESNA Illuminance Recommendations (9th Edition Handbook)**
- Mood and atmosphere.
- Visual comfort.
- Aesthetic judgment.
- Health safety and well being.
- Social communication.

Unnecessarily high light levels waste energy

Low light levels affect learning, maintenance and security

Classrooms 30-70 footcandles (fc)

Gyms 40-50 fc

Multi-purpose rooms, cafeterias 20-40 fc

Library Reading Areas 40-60 fc

Computer Areas 20-30 fc

Lighting for Human Needs

- Visibility and task performance.
- Mood and atmosphere →
- Visual comfort.
- Aesthetic judgment.
- Health safety and well being.
- Social communication.

Use modern high quality electric light sources.

- Lamps 3500K or 4100K
- CRI >80

Use wall and ceiling brightness to create mood. *Bright surfaces = cheerful and clean. Dark surfaces = dramatic.*

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Lighting for Human Needs

- Visibility and task performance.
- Mood and atmosphere.
- Visual comfort →
- Aesthetic judgment.
- Health safety and well being.
- Social communication.

Employ design principles of visual comfort

Shield bright lamps and daylight from normal viewing angles

Illuminate the ceiling and upper walls as well as the task

Minimize extreme differences in surface reflectivity

Provide ambient light levels at least 1/3 task light levels

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Lighting for Human Needs

- Visibility and task performance.
- Mood and atmosphere.
- Visual comfort.
- Aesthetic judgment →
- Health safety and well being.
- Social communication.

Choose lighting and daylighting systems to be part of an appealing design

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Lighting for Human Needs

- Visibility and task performance.
- Mood and atmosphere.
- Visual comfort.
- Aesthetic judgment.
- Health safety and well being →
- Social communication.

Health. The strongest relationship between light and human health are circadian rhythms which can be reinforced with daylighting.

Safety. Meet IESNA recommendations indoors and out.

Well being. Make spaces feel more enjoyable and enable them to be used effectively.

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Lighting for Human Needs

- Visibility and task performance.
- Mood and atmosphere.
- Visual comfort.
- Aesthetic judgment.
- Health safety and well being.
- Social communication →

Design lighting to encourage appropriate social activity. Provide layers of light to create different moods and uses.

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Challenge: Balancing Human Needs with Architecture, Site and Other Design Constraints

- "Lighting design" is the process of meeting design criteria with electric lighting and daylighting choices
- Especially dependent on the ceiling height and coordination of ceiling elements including HVAC and fire protection systems
- Includes functional, aesthetic and practical decisions among several design team members
- Tends to favor more expensive solutions - better quality luminaires with appeal.

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Balancing Human Needs with Economics and the Environment

- Where "High Performance" lighting technology and techniques have the greatest impact.
- First cost issues tend to favor less efficient, less appealing and higher maintenance solutions.
- Life cycle cost analysis tends to favor energy efficient, low maintenance solutions.
- Human needs tend to favor more expensive, more appealing solutions.
- This is where the CHPS Manual can help the most: finding the best compromises for today's schools.

Environmental and Life Cycle Cost Issues

- Largest Issue: Energy Efficiency
  - Lighting energy costs are among the largest utility costs of the school
  - Modern designs can use 50% of the energy of 80's and early 90's designs.
- Next: Lighting Maintenance
  - Modern lighting systems can require 50% less maintenance costs if chosen correctly.
- Lamp Disposal
  - Low Mercury lamps reduce environmental risk and liability.
- Better Exterior Lighting
  - Prevents light pollution and light trespass, makes a school a better night time "neighbor"

Daylighting and Electric Lighting

Daylighting

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A Renewed Interest in Daylighting: The Next Major Design Challenge

- Makes interior spaces more pleasant and appealing
- Recognized as a significant aid in academic performance.
- Can provide significant energy cost savings.
  - Peak savings tend to occur at peak demand and peak rates
- A very large percentage of California schools are in nearly ideal climates for daylighting
  - Minimum temperature differential indoors to outdoors
  - Very high daylight availability

What is "Daylighting Design"?

- Designing spaces to use diffuse light from the sky.
- Use daylighting to provide the PRIMARY illumination within a space.
- Design the electric lighting system to SUPPLEMENT the daylight.
  - Make sure it is turned off when not needed.
  - Provide adequate light when no daylight is available.
- Includes the design of architectural and interior elements such as light shelves and shades to control daylight quantity and quality.

What is NOT Daylighting?

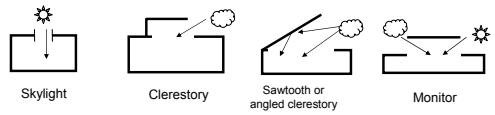
- Too much daylight – a solar oven
- Incorrectly massed and oriented buildings
- A building with good daylight illumination BUT the electric lights burning away.

Direct sunlight is usually not good daylight

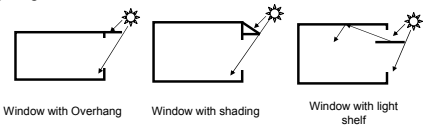
- Too bright, causing contrast and visual comfort problems.
- Significant infrared radiation causes local thermal discomfort
- Does not diffuse the light, making use of electric lighting necessary and increasing the cooling load

Basic Types of Daylighting

Toplighting



Sidelighting



Basic Principles of Solar Orientation

Worst Exposure

- North and south ends provide minimum interior light
- East and west sides tend to introduce too much light and heat
- East and west sides require complex shading systems
- Shading often requires blocking view glazing

Ideal Exposure

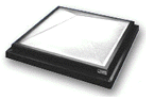
- North side can introduce a maximum of diffuse daylight
- South side can be passively shaded most of the year without blocking view glazing
- East and West sides can have minimal fenestration

Daylighting Design Principles

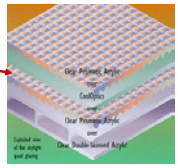
- Allow NO direct sun penetration,except in circulation spaces.
- Diffuse the light broadly through diffusing glazing and/or shading.
- Introduce daylight as high as possible,
- Use light colored surfaces.
- Keep brightest surfaces out of line of sight.
- Provide blinds or louvers where there is potential for glare or for audio-visual control.

Skylights – Simple and Reliable Daylight

Consider skylights whenever possible in single story buildings and the upper level of multi story buildings. Use diffuse or prismatic skylights in most cases. Skylights with internal louvers are an excellent option for light level control but add cost.

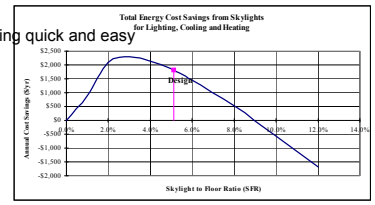


- Proper sizing needed. Use SkyCalc or equivalent.
- Consider modern skylights using prismatic refractors, specular throats and other technologies to increase efficiency, allow smaller skylight to floor ratio (SFR).
- "Cool" skylights with low-e type filtering now available – check them out.
- Skylights are:
  - Effective all day long.
  - Effective under sunlight or cloudy skies.
  - Comparatively inexpensive.
  - Relatively independent of building orientation.

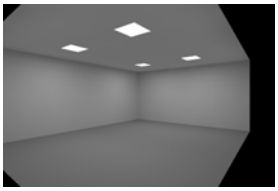


New Design Tool - SkyCalc

- Skylight design tool
- Standard Excel Spreadsheet Template (www.savingsbydesign.com)
- Readily available data for most of California Climate Zones
- Built-in basic lighting calculations, energy cost analysis, and other useful information
- Makes skylight sizing quick and easy
- Accounts for
  - Heating
  - Cooling
  - Lighting
  - Energy Rates
  - Occupancy/use



Example: Classroom Design Using SkyCalc



PROJECT: Washington School for the Deaf

Typical small classroom 20 x 25, 10' ceiling

Original Daylight Concept

Single Center Skylight 8' x 8' clear. Total of 64 SF (12.8% SFR) with VLT =50%

Average light level: 604 fc (equinox clear)

Peak light level: 3928 fc

Typical light level: 80-100 fc

Minimum light level: 63 fc

Recommended Daylighting Revision

4 diffuse skylights, 2' x 2' , total of 16 SF (3.2% SFR) with VLT=50%

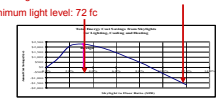
Average light level: 121 fc (equinox clear)

Peak light level: 172 fc

Typical light level: 80-100 fc

Minimum light level: 72 fc

12.8% SFR



Example: Two Gymnasiums (SkyCalc = 4% SFR)

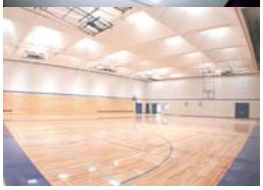
Ferris Spanger Elementary, Roseville

Four large (8' x 16') skylights 50% VLT 4% SFR

Average light level 200 fc (equinox clear)

Maximum light level 335 fc

Minimum light level 83 fc



Twenty small (4' x 4') skylights 60% VLT 3.33% SFR

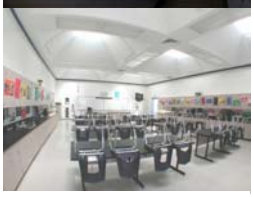
Average light level 142 fc (equinox clear)

Maximum light level 172 fc

Minimum light level 80 fc

(Calculations for Sacramento)

Example: Skylights with Louvers



1440 SF Large Classroom.

Demonstrating "daylight dimming" using internal louvers in skylighting system.

Salida Middle School, Vella Campus

Ken Kaestner, Architect.

Example: Toplighting (with Clerestory)

North Clackamas High School

BOORA, Architects

Sidelighting

Daylight with a View – and complexity

- Consider using windows and clerestories to provide daylight when toplighting is not practical.
- Solar orientation is critical. Windows must be shaded on the south, east and west faces. Light shelves with combination clerestory/view windows can be used on the south face. Window walls and high clerestory windows can be clear on the north face – on the east, south and west faces, diffusion and shading is needed.
- Two side lighting is much better than one side.
- Shaped ceilings can improve the performance of sidelighting.

Two Sides of Light - a very good thing
Oakridge High School

Carefully Integrated Sidelighting with Shelf and Angled Ceiling

North Clackamas High School

Sidelighting for the Library

North Clackamas High School

Related Daylighting Design Considerations

Structural Issues

- Roof penetrations
- Additional reinforcing

Classic Concerns

- Noise Control.
- Safety and Security.
- Air and Water Leakage.
- Condensation.
- Fire Protection.
- Visual Privacy.
- Maintenance and Replacement.

Modern Daylighting Analysis Using Models

- Daylight Factor Calculations
- Use of Scale Models
  - Best studied under both an artificial sky (diffuse light) and heliodon (direct solar radiation)
  - Can also be studied outdoors
- Benefits of Model Methods
  - Hands on three dimensional study
  - Daylight scales perfectly
  - May allow reconfiguration
  - Allows understanding of what works and why

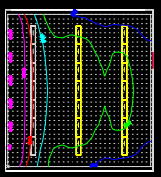
Modern Daylighting Analysis Using Radiosity

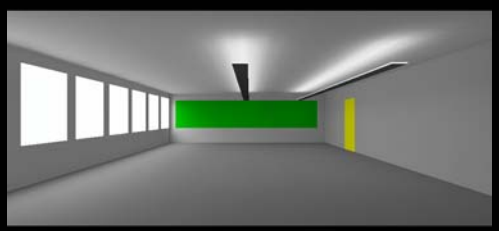
Modern lighting software permits daylighting analysis in lighting terms.

- Rapid 3-D modeling using simple primitive models
- Rapid calculation time allows analysis under many conditions
  - Time of day
  - Time of year
  - Weather condition
  - Different glazing conditions

Example: Classroom, West Face, Daylighting, No Shelf/No Shade

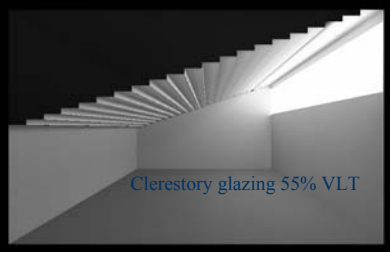
June noon, cloudy.. Most of room between 50 and 200 fc Supplemental two rows of lights near inner wall calculated “on”.





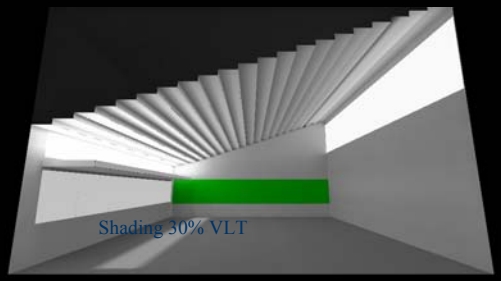
Example: Clerestory, North Facing

Summer, sunny, noon. Average light level 75 fc, min. 35 fc, max 125 fc.



Example: Daylight, north facing clerestory, south facing window with shelf and shade

December, sunny, noon. Daylight is 189 fc average, 500 max, 73 minimum.



Daylighting and Electric Lighting

Daylighting Guidelines

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CHPS has Eight Daylighting Guidelines:

Guideline

- View Windows.
- High Sidelighting (clerestory).
- Clerestory with lightshelf.
- Wall Wash Toplighting.
- Central Toplighting.
- Patterned Toplighting.
- Linear Toplighting.
- Tubular skylights.

View Windows (Guideline DL1)

Guideline

Make view glazing a priority in classrooms, cafeterias, offices and most other spaces.

- Provides view.
- Transparency.
- Ventilation.
- Limited daylight
  - Use to balance other strategies.
- Address glare.
- Address user control.

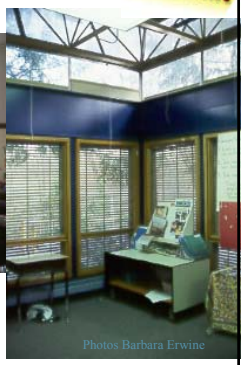
Clerestories (High Windows) (Guideline DL2)

Guideline

Use clerestories when ceiling height and solar orientation permits

- The higher, the better !
- Bounce light off of:
  - Roofs
  - Sidewalks
  - Overhangs
- Avoid low sun angle penetration into space.

Clerestory with View Windows



- Control view-windows and clerestories separately!

Clerestory with Lightshelf (Guideline DL3)

- Bounces direct sunlight
  - South walls only.
- Ineffective in cloudy conditions
  - or to E, W, N.

Wall Wash Toplighting (Guideline DL4)

- An indirect lighting technique using a clerestory or light well
- Broadly diffusing, low glare
- Permits otherwise poor solar orientation

Central Toplighting (Guideline DL5)

- Use broad splays to illuminate walls
- Use SkyCalc to size skylights
- Consider optional louvers to modulate daylight and/or provide for audio visual needs

Patterned Toplighting (Guideline DL6)

- Use SkyCalc to determine skylight sizes
- Consider new “cool” skylights and high efficiency specular throats
- Consider internal louvers to modulate daylight and permit black-out

Linear Toplighting (Guideline DL7)

- Excellent for core areas.
- Alternate patterns
  - Ridge top skylighting.
  - Linear monitors.
  - Step-roofed section with clerestories.

Tubular Skylights (Guideline DL8)

Guideline

- Traditional light commercial units 8" to 16" diameter.
- New 22" diameter commercial grade units.
- Reflective, flexible tubes.
- Collector at top, diffuser at bottom.
- Use for offices, small spaces, deep ceilings, retrofits.
  - 75 - 150 ft^2 per tube.

Daylighting and Electric Lighting

Electric Lighting

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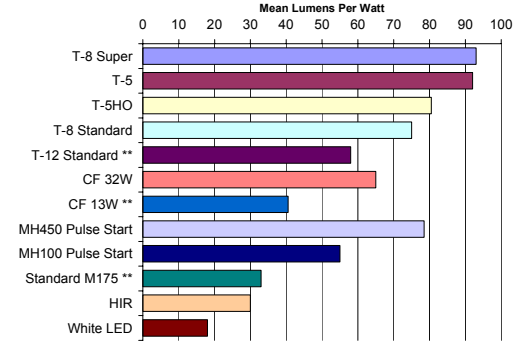
Select Proper Electric Light Sources

- Efficacy (lumens per watt)
  - Determines the efficiency of converting electricity to light.
  - The higher the efficacy the better.
- Color Temperature
  - We tend to prefer "white" light sources between 3000K ("warm") and 4100K ("cool"). We might consider 5000K (cold) for studios.
- Color Rendering Index
  - Measures light source quality.
  - Sources with CRI < 70 are noticeably distorted. CRI<60 unacceptable.
  - Whenever possible choose light sources with CRI > 80.
- Lamp Life
  - Choose lamps with maximum life possible to minimize maintenance.
- System Costs
  - Choose systems that employ low cost lamps and ballasts.

Comparison of Lamp Efficacy



Electronic ballasts except where noted by **

The King of the Hill: Super T8 is a SYSTEM

- Standard 32 watt T-8 lamps with high initial lumens, high lumen maintenance, and long life construction
  - GE "HL" series
  - Sylvania "XPS" series
  - Phillips "Advantage" series
- New High Efficiency "Super" Electronic Ballasts
  - Standard 2-lamp T8 ballast is 59 watts – super ballast is 53 watts
- Optional instant start ballasts give 99 mean lumens per watt and should be used where lights are turned on and left on
- Optional program start ballasts give 92 mean lumens per watt and provide extended lamp life, especially when frequently switched.

For Primary Lighting Systems: Linear Fluorescent Lamps

- T-8 "Super" Lamps
  - 93 MLPW vs. 75 MLPW for ordinary T-8.
  - 85+ CRI.
  - 30,000 hour lamp life on program start electronic ballasts.
- T-5 Standard Lamps
  - 91 MLPW.
  - 83+CRI.
  - 20,000 hours + life.
- T-5 HO
  - 80 MLPW.
  - 83+CRI.
  - 20,000 hours life.

Secondary and Special Lighting Systems

- Compact fluorescent lamps
  - 10,000 hour lamp life.
  - 50-65 MLPW varies with wattage.
  - High CRI >80.
  - Color temperature 3000K, 3500K, 4100K, and others.
  - NOW – use 57 watt and 70 watt compact fluorescent INSTEAD of low wattage metal halide!
- Pulse start metal halide lamps
  - 50-79 MLPW varies with wattage.
  - 7,500 to 20,000 hour lamp life.
  - Standard lamps CRI 65-70.
  - Ceramic high color lamps CRI>80.
  - Long warm up and restrike times.
  - PREFER THE CERAMIC METAL HALIDE LAMPS FOR SUPERIOR COLOR

Light Sources for Limited Use

- Halogen IR lamps
  - Excellent CRI ~100.
  - Color temperature warm 2850-3000K.
  - Highly directional.
  - Inexpensively dimmable.
  - Life 3000-4000 hours.
  - Efficacy 20-30 MLPW.

Why Not High Pressure Sodium or Low Pressure Sodium Lamps?

- High pressure sodium lamps produce a pinkish yellow light.
  - CRI <20.
  - Color temperature <2200K.
  - Provides poor visibility for indoor tasks, including problems with focusing on small work.
  - Provides decreased peripheral vision and response time in outdoor lighting.
- Low pressure sodium lamps produce monochromatic yellow light.
  - CRI = 0.
  - Worse than high pressure sodium in all respects.

Light Source Applications

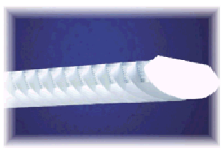
	General (Indoor)	Special & Utility (Indoors)	Display & Mood (Indoors)	Outdoor Lighting
Linear Fluorescent	+ +	+		
Compact Fluorescent		++	+	+
Metal Halide		+	+	++
HIR Tungsten Halogen			+	

Know Your Ballasts

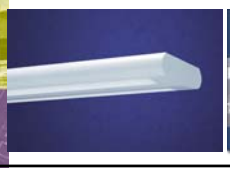
- Use electronic ballasts exclusively for fluorescent and compact fluorescent lamps.
  - For T-8 lamps, investigate “low light output” and “high light output” ballasts to fine tune fixture watts to the minimum needed for a space.
  - Dimming ballast prices are still high – carefully evaluate the need for dimming.
  - Low temperature ballasts permit compact fluorescent lamp starting and operation at <0º ºF.
- Use electronic ballasts for metal halide lamps up to 150 watts (and maybe higher).

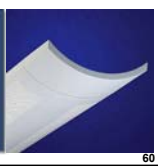
Choose Suspended Luminaires for Efficiency and Comfort

A wide range of choices for indirect, semi-indirect and direct/indirect lighting.
Must have 9’6” ceiling min.



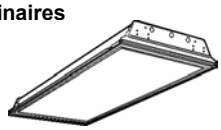
- Seek efficient luminaires
- Carefully compare Super T8 and T5HO systems, especially for indirect systems.





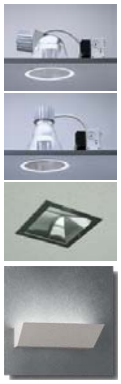
If You Must…Recessed Luminaires

- Use recessed luminaires in conjunction with t-bar grid ceilings in low ceiling applications.
  - Lens troffers are very low cost and efficient solutions.
  - Basket style troffers offer similar performance but are more appealing.
  - Parabolic troffers are very commonly used in a number of space types.



Occasional Luminaires

- Use recessed downlights both in t-bar grid ceilings and hard lid ceilings.
  - Compact fluorescent downlights for most interior and many exterior applications.
  - Metal halide downlights in high bay applications and outdoors.
  - Halogen downlights and accent lights in special "social" spaces and A/V environments.
- Compact fluorescent and HID wallwashers
- Durable wall sconces
  - Incandscent in theaters and AV spaces
  - Compact fluorescent in corridors, offices, other low abuse settings
  - HID in pools and some large spaces



Decorative and Stylish Luminaires

- Add a touch of style
- Use in low abuse "special" locations
  - Major entries and lobbies
  - Commons areas
  - Cafeterias
  - Libraries
- All of these are compact fluorescent

Surface-mounted High Abuse Luminaires

Choose T-8, T-5, HID or compact fluorescent luminaires for a number of occasional and utility applications such as:

- Stairwells.
- Exterior doors.
- Locker and toilet rooms.
- Showers.

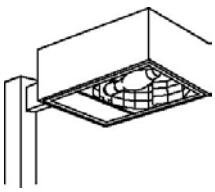
Specialty Luminaires for Gyms and other Big Spaces

High bay fluorescent is the probably the most energy efficient choice for large spaces like gyms. The 6-lamp T5HO fixture at 360 watts exceeds the maintained performance of a 400 watt metal halide operating at 458 watts. Optional uses include 1/3, 2/3 and 3/3 light level operation for energy savings.

High performance metal halide downlights are still a good choice for large gyms and field houses when lights must be left on for many hours a day and mounting heights are very high (>40').

Outdoor Luminaires

- Typically you will use a combination of:
- Parking lot lights, preferably "shoe box" pole lights to control light trespass and light pollution.
- Architectural pole lights for drives and entries.
- Bollards for near buildings and plazas.
- Special sports lighting for high schools and above.



Exit Signs

- Unless otherwise required by code use LED exit signs.
- Red or green depending on local authorities.
- Use very low power making them especially easy to equip with their own backup battery.
- Remember, LED exit signs don't have a downlight egress light - you will need to provide that.

Daylighting and Electric Lighting

Lighting Controls

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Lighting Controls for Schools

- Title 24 requires automatic shutoff controls. Teachers do not qualify.
- Common areas: use time of day, programmable control, relay panel systems
  - Meets code
  - 365 day programming permits planned operation
  - Local override controls and motion sensor security/safety controls permit off schedule operation
- Classrooms, Offices: use motion sensors in series with standard toggle switches
  - Permits two or more levels of control meeting Title 24 two level switching requirements
  - Allows teachers to control their spaces
- Gyms
  - Consider frequent switching with fluorescent high bay systems

Electric Lighting Rules-of-Thumb

- Design control circuits PARALLEL to the daylight contours.
- Provide a minimum of two levels of illumination
  - Dimming is nice but costly.
- Allow user over-ride of automatic controls.

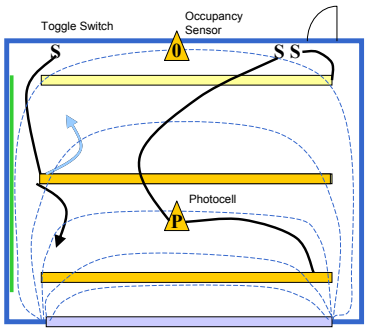
Lighting Controls Basic Principles

- Turn off lights when spaces are not in use.
- Turn off lights when there is adequate daylight.
- Dim lights if daylight levels vary.
  - Stepped dimming
  - Full range dimming
- Dim lights according to need.
  - Stepped dimming is fine in many spaces
  - Full range dimming is costly but works better.

Integration with Daylight

- Ensure harvesting of available daylighting.
  - Use daylighting controls.
  - Study spaces to determine appropriate daylight amounts.
- Provide daylight glare management.
  - Determine direct solar glare situations.
  - Design manual or automatic blinds or other means of reducing the direct solar exposure glare and excessive light levels and heat gain.

Simple Classroom Controls



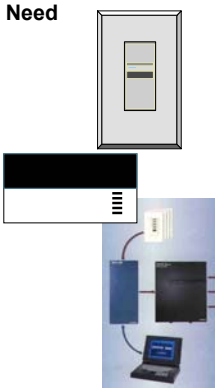
Appropriate for windows on one side of room.

An inexpensive switching solution with maximum control options.

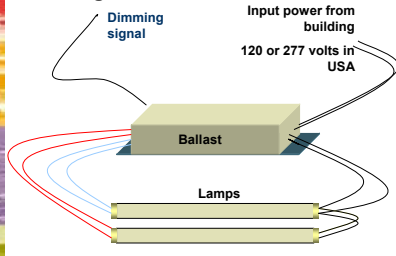
Dual technology occupancy sensor, manual on / automatic off.

Dimmers for When You Really Need Them

- Manual Dimmers
  - For single rooms and single circuits.
- Preset Dimmers
  - For A/V spaces and social spaces.
- Dimming Systems
  - For managing large facilities and integrated systems.



Dimming Ballasts for Fluorescent Lamps



In modern electronic ballasts, dimming occurs INSIDE the ballast.

There are 4 INCOMPATIBLE types of electronic dimming ballasts:

- 3 wire forward phase cut (Lutron, Lightolier)
- 2 wire forward phase cut (Advance, Lutron)
- 0-10 volt analog (Lutron, Advance, Universal, Sylvania, others)
- Digital DALI (Sylvania/Siemens, Tridonic, Lutron, others)

Daylighting and Electric Lighting

Design Tools

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For Design, Use Modern Analysis Tools

Lighting Calculation and Illustration Programs are readily available to provide point by point calculations and other capabilities.

- Tools to enable better lighting design results.
- Permit exacting calculations.
- Help execute challenging designs.
- Understand natural lighting effects.
- Understand electric/natural lighting interaction.
- Help visualize results.

Lighting program types

- Radiosity only
  - Acceptably accurate.
  - Fast execution.
  - Simple renderings.
- Pure Ray-tracing
  - Can be very accurate.
  - Slow input and slow execution.
  - Potential for photorealistic renderings.
- Latest: radiosity with ray-tracing renderings
  - Fast, easy and spectacular renderings

Daylighting and Electric Lighting

Electric Lighting Guidelines

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Electric Lighting Guidelines

Guideline

- Pendant Mounted Lighting (Guideline EL1).
- Recessed Lighting (Guideline EL2).
- Surface Mounted Lighting (Guideline EL3).
- Lighting Controls for Classrooms (Guideline EL4).
- Gym Lighting (Guideline EL5).
- Corridor Lighting (Guideline EL6).
- Multi-Purpose Room (Guideline EL7).
- Library or Media Center (Guideline EL8).
- Offices and Teacher Support Rooms (Guideline EL9).
- Locker and Toilet Rooms (Guideline EL10).
- Outdoor Lighting (Guideline EL11).

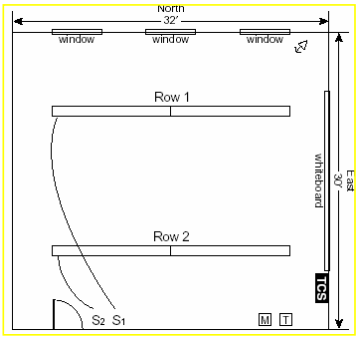
Pendant Mounted Lighting (Guideline EL1)

Guideline

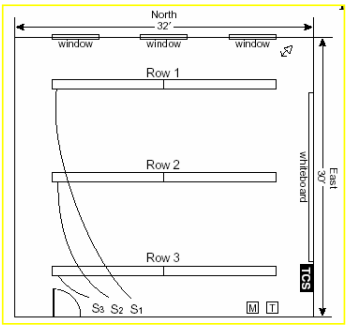
- If ceilings > 9'-6", use suspended fluorescent lighting:

Semi-indirect or indirect distribution	> 85% luminaire efficiency, T-8 super or T-5HO, electronic ballasts. (Connected lighting power = 0.85 to 1.0 W/sf)
Direct/indirect distribution	75% luminaire efficiency, T-8 "super", electronic ballasts. (Connected lighting power = 0.85 to 1.0 W/sf)

2 rows of 8 pendant mount 3 lamp super T8 fixtures – indirect, semi indirect or direct/indirect

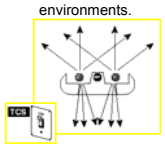


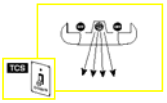
3 rows of 8 pendant mount 2 lamp super T8 fixtures – indirect, semi indirect or direct/indirect



Preferred: The PIER Classroom Lighting System

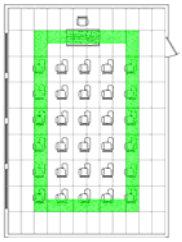
Use three lamp luminaires with separate direct and indirect lamps to provide for normal and AV environments.





Recessed Lighting (Guideline EL2)

- Use only when:
  - Low ceilings inappropriate for suspended luminaries.
  - Limited budgets.
- Use recessed fluorescent lens troffers
  - >78% luminaire efficiency.
  - T-8 premium lamps.
  - Electronic ballasts.
  - (Connected lighting power = 0.8 to 1.0 W/sf).



Surface Mounted Lighting (Guideline EL2)

- For rooms with ceilings less than 12' which cannot use recessed or suspended lighting systems because:
  - Ceiling height is 8' 6" or less, preventing use of suspended luminaires.
  - Ceiling cavity is impenetrable (because of asbestos, or roof insulation, etc).
  - Design uses a hard ceiling surface (e.g. wood) that has a moderate reflectance.
- Recommendations:

Short stem-mounted semi-direct fluorescent luminaires	> 65% efficiency, super T-8 system. (Connected lighting power = 1.0 to 1.1 W/sf).
Surface-mounted fluorescent lens troffers	> 78% efficiency, super T-8 system. (Connected lighting power = 0.9 to 1.1 W/sf).

Classrooms Lighting Controls (Guideline EL4)

- Motion sensing with manual override.
- Separate switches for lights near a side window and for lights near an interior wall.
- Automatic daylight switching or dimming is an option.

Gym Lighting (Guideline EL5)

- Consider current alternatives for gym lighting:
  - T-5HO and T-8 "High-Bay" gym lights.
  - High performance metal halide industrial style lights.
- Provide daylighting and multi-level controls
- Also, consider:
  - Emergency lighting.
  - Other "social" or "house" lighting systems.

Corridor Lighting (Guideline EL6)

- Recessed fluorescent luminaires
  - Protect lamp and create relatively high angle light.
- Surface mounted corridor "wrap around" fluorescent luminaires
  - Designed for rough service applications.
- T-5 or T-8 lamps and electronic ballasts.
- Try to avoid luminaires which appear overly "institutional".
- Align luminaires parallel to corridor walls
  - Good light quality and to illuminate lockers.
- Outdoor corridors and corridors with plentiful daylight should use automatic daylight switching or dimming.
- Emergency lighting may be necessary.

Multi-Purpose Room (Guideline EL7)

- Consider various functions/social uses of multipurpose spaces.
- A general lighting system
  - 20-30 fc of uniform illumination with standard T-8 lamps.
- A dimmable "house lighting" system for AV and social events
  - No more than 5 fc.

Library or Media Center (Guideline EL8)

Guideline

Reading/circulation/seating:	20-50 fc using T-8 or T-5 lamps
Circulation desks, etc.:	Overhead task lighting
Carrels:	Task lighting with CFL or T-8 lamps
Fixed stacks:	Stack lights using T-8 or T-5 lamps
High density stacks:	General overhead lighting

Offices and Teacher Support Rooms (Guideline EL9)

Guideline

- Suggests two very different designs

For Low Ceilings and Low Budgets: Recessed fluorescent lens troffers	> 78% luminaire efficiency, T-8 premium, electronic ballasts. (Connected lighting power = 0.8-0.9 W/sf)
Wherever possible: Suspended indirect lighting	General light levels of 30-50 fc (about 0.9 w/sf) and task lighting where required.

Locker and Toilet Rooms (Guideline EL10)

Guideline

Over mirrors/vanities:	Rough service grade fluorescent wall-mounted lights.
Over stalls/lockers:	Recessed or surface-mounted rough service fluorescent lights.
Showers:	Ceiling-mounted, watertight, rough service grade fluorescent lights.

Outdoor Lighting (Guideline EL11)

Guideline

At every door:	canopy or wall-mounted lights to illuminate the general area.
Parking lots:	pole mounted lights to illuminate the lot and surrounding walks and other areas.
Driveways:	pole mounted lights for the drive and associated sidewalks.
Walkways:	walkway lighting systems such as pedestrian light poles or bollards.
Everything Else:	other lighting as called for by the site, local requirements, etc.

Daylighting and Electric Lighting

The CHPS Classroom

Electric and Natural Light Working Together

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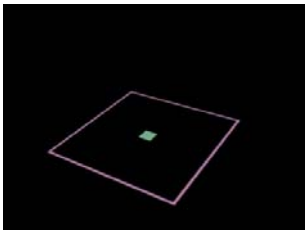
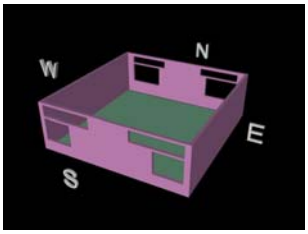
High Ceilings

- Average classroom is 30' x 30'.
- High ceilings enhance space and provide better illumination, ventilation. and acoustics.
- Floor-to-ceiling height should be at least 10'.



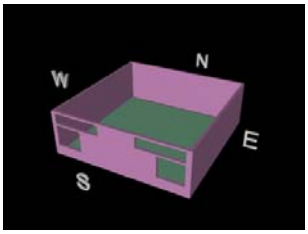
Orient Windows North/South

- Windows should be oriented either north or south.
- Locate windows at edges of room to prevent dark corners and wash teaching wall.
- If possible, increase the amount of window glazing. This will increase visual comfort and indoor environmental quality - but may cost more.



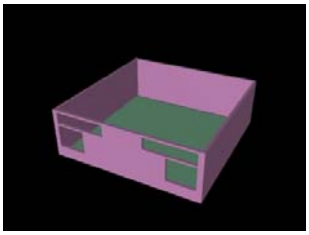
Skylights

- Skylights or clearstories should be used to illuminate the back wall of the classroom.
- Light shelf also acts to shade the vision section of the window.
- Use skylights with prismatic or diffuse glazing to diffuse light.
- Treat skylights like light fixtures - one big one is a very bad idea.



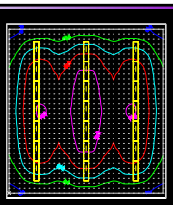
Electric Lighting

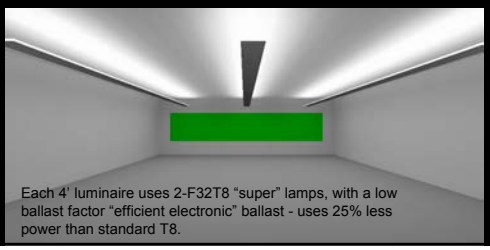
- Two or three rows of pendant-mounted electric lights are positioned parallel to the window wall.
- Use direct/indirect, semi indirect, or indirect lighting
- Design connected power at around 0.9 w/sf using state of the art technology



Classroom, State of the Art Electric Lighting

Direct/indirect lighting, 0.90 w/sf, all of room over 40 fc most over 50 fc mean.

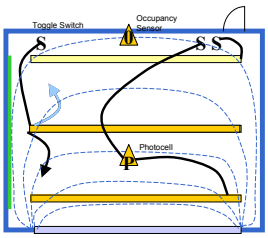




Each 4' luminaire uses 2-F32T8 "super" lamps, with a low ballast factor "efficient electronic" ballast - uses 25% less power than standard T8.

Lighting Control

- Occupancy sensors shut off lights if room is unoccupied.
- Separate controls for each light based on daylighting availability.



Appropriate for windows on one side of room.

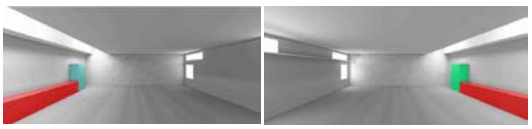
An inexpensive switching solution with maximum control options.

Dual technology occupancy sensor, manual on / automatic off.

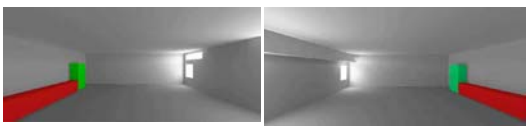
Design Daylighting

North wall view

South wall view



Two Sided Daylighting (preferred)



Side lighting only

Small windows with shear wall

Conclusions

- The Best Practices Manual can help you achieve:
  - >25% less lighting energy use than Title 24 without daylighting controls.
  - >40% less lighting energy use than Title 24 with daylighting controls in spaces with windows but no special daylighting provisions such as skylights.
  - >65% less lighting energy use if additional skylights are provided in appropriate and effective spaces such as gyms.
- Basic lighting systems competitive with traditional costs and approaches.
- A reasonable assurance of long term maintainability, low operating and maintenance costs, and good results.